RFCA Stakeholder Focus Group
Meeting Agenda

When: **April 17, 2002 3:30 – 6:30 p.m.**

Where: **Broomfield Municipal Hall, Bal Swan and Zang's Spur Rooms**

3:30-3:40	Ground Rules, Agenda Review, Objectives for this Meeting
3:40-4:25	Agency Response to RSALs Task 3 Peer Reviews – Presentation and Group Discussion
4:25-5:10	RESRAD and Risk Recalculation – Presentation and Group Discussion
5:10-5:20	Break
5:20–6:20	Uranium Surface RSAL Calculation and Draft Modeling Results – Presentation and Group Discussion
6:20-6:30	Set Next Agenda
6:30	Adjourn

1/42

April 10, 2002

Dear Stakeholder:

The Rocky Flats Cleanup Agreement (RFCA) Stakeholder Focus Group will meet at the Broomfield Municipal Center at One DesCombes Drive on April 17, 2002 from 3:30 to 6:30 p.m.

The agenda for the April 17 meeting is enclosed (Attachment A). We will discuss the following topics:

- Agency Responses to RSALs Task 3 Report Peer Reviews
- RESRAD and Risk Recalculations
- Uranium Surface RSAL Calculation and Draft Modeling Results

The handouts from the March 20, 2002 RFCA Focus Group meeting are enclosed as Attachment B, and include:

- Agency Response presentations to RSALs Task 3 Report Peer Reviews.

Attachment C is the RSALs Working Group Meeting Notes for the March 28, April 4, and April 11, 2002 meetings.

Also attached (Attachment D) are two documents that were developed by the RSALs Working Group meeting of April 11, 2002. Please read the following attached materials for the April 17 meeting:

- Draft RSAL Recalculations: Responding To Task 3 Comments And Quality Checks (RESRAD Dose Calculations Only), and
- Draft Addendum To Task 3 Report: Computations Of RSALs For Uranium Contamination At Rocky Flats Using RESRAD 6.0 (Dose-Based Computations)

Attachment E is the October 3, 2001 meeting minutes.

You may call either Christine or me if you have any questions, comments, or suggestions concerning the RFCA Stakeholder Focus Group or the upcoming meeting.

Sincerely,

C. Reed Hodgin, CCM
Facilitator / Process Manager

RFCA Stakeholder Focus Group
April 17, 2002
Meeting Minutes

INTRODUCTION AND ADMINISTRATIVE

A participants list for the April 17, 2002 Rocky Flats Cleanup Agreement (RFCA) Stakeholder Focus Group meeting is included in this report as Appendix A.

Reed Hodgin of AlphaTRAC, Inc., meeting facilitator, reviewed the purpose of the RFCA Focus Group and the meeting rules. Introductions were made.

AGENDA

Reed reviewed the agenda:

- Agency Responses to RSALs Task 3 Report Peer Reviews;
- RESRAD and Risk Recalculations; and
- Uranium Surface RSAL Calculation and Draft Modeling Results.

AGENCY RESPONSES TO RSALs TASK 3 REPORT PEER REVIEWS

Reed asked if there were further comments or requests regarding the latest version of Task 3 before the document is finalized.

The Focus Group had no further questions or comments. Reed asked that in the event questions or comments arose, please forward them to Christine Bennett of AlphaTRAC and Christine would ensure that the agencies received them.

RESRAD AND RISK RECALCULATIONS

The Environmental Protection Agency (EPA) made two presentations:

1. Recalculated dose-based RSALs for Plutonium and Americium; and
2. Risk Recalculations Discussion.

Recalculated dose-based RSALs for Plutonium and Americium

Dose calculations were performed using the RESRAD 6.0 model for the *Draft Task 3 Report*. Five exposure scenarios were addressed: wildlife refuge worker, rural resident, open space user, office worker, and resident rancher. Plutonium and Americium activity concentrations in surface soil were calculated for a 25 millirem (mrem) annual dose. Original results were summarized in pages one and 49 of the *Draft Task 3 Report: Dose and Risk Calculations for Plutonium in Surface Soil Adjusted by Sum-of-Ratio Method (pCi/g)* and *Table V-2. Dose and Risk Calculations for Americium in Surface Soil Adjust by Sum-of-Ratios Method (pCi/g).*

These results were recalculated using a different adult soil ingestion value in the RESRAD 6.0 model.

The presentation for the recalculations was organized into two sections:

- Differences in Parameters; and
- Results: New / Previous Sum of Ratios in picoCuries per gram (pCi/g).

Differences in Parameters

Changes in parameters resulted from comments from peer reviewers.

Basically, all of the parameters that were used in all of the different scenarios were identical with one exception—a different parameter for the adult soil ingestion. This new calculation used a uniform distribution ranging from 0 to 130 milligrams per day (mg/day). The old point estimate used was 100mg/day.

Also, corrected was an inconsistency. It was discovered that the soil ingestion needed different apportioning for the open space user and office worker scenarios. For example, an adult open space worker may ingest up to 50mg of soil each day that they are on the site. If they are only on the site for 2 hours, then the RESRAD inputs were adjusted to 50mg/day for a 2-hour visit for 100 days a year. This adjustment resulted in a different answer.

One reviewer commented that the risk equations did not have a provision for calculating full ingrowth of Americium. As a result, the maximum value of Americium, which is 18.2%, was used instead of the measured value of 15.3%. This added a level of conservatism.

Results: New / Previous Sum-of-Ratios in pCi/g

The following results have been adjusted by sum-of-ratios and are the recalculated results for each scenario. The recalculated result appears on the left-hand side **in bold**. The earlier result appears on the right-hand side.

Revised Dose Calculations for Plutonium and Americium in Surface Soil Adjusted by Sum-of-Ratios – pCi/g (25-mrem annual dose)

Scenario	Pu RSAL	Am RSAL
Wildlife Refuge Worker	**780**/862	**142**/132
Rural Resident – Adult	**232**/209	**42**/32
Rural Resident – Child	**251**/244	**46**/37
Open Space – Adult	**3617**/11797	**658**/1801
Open space – Child	**1205**/4842	**219**/739
Office Worker	**1598**/2289	**290**/350

A general trend was the relationship between Americium to Plutonium and the recalculations resulting in a higher RSAL, with the exception of the wildlife refuge worker. This was due to the fact that the distribution was multiplied by a factor of three in order to assign the 130 mg/day of soil ingestion for 8 hours. The RESRAD model would not convert certain data, so this was a forced input.

Recalculated RSALs for the three CERCLA risk levels (i.e., 10^{-4}, 10^{-5}, 10^{-6}) were not included in this presentation.

Summary

- Americium RSALs go up relative to Plutonium because of the higher equilibrium ratio.
- The decrease in RSALs for open space user and office worker are consistent with the risk approach used previously; and
- The changes to the refuge worker and the rural resident values were not considered significant.

Risk Recalculations Discussion

The EPA reviewed the changes to the Plutonium and Americium risk calculations. As previously noted at the March 20, 2002 RFCA Focus Group meeting, the cancer slope factors were not representative of adult-only soil ingestion rates, as it was previously calculated using an averaged adult / child number called a "mixed slope factor." Revisions to the spreadsheets have been completed using the new adult-specific cancer slope factor provided by EPA Headquarters. These revisions also included using point estimate and probabilistic approaches for adult soil intake rate. New risk-based point estimate and probabilistic RSALs for scenarios were provided as a part of the presentation and act as amendments to the following tables in the *Draft Task 3 Report dated 10/22/01:*

- *Table V-3 Risk Based Probabilistic RSALs for Individual Radionuclides for the Rural Resident* **replaced by *Table V-3a. Risk-based Point Estimated and Probabilistic RSALs for Individual Radionuclides for the Rural Resident.***
- *Table V-4 Risk-Based Probabilistic RSALs for Individual Radionuclides for Wildlife Refuge Worker* **replaced by *Table V-4a. Risk-based Point Estimate and Probabilistic RSALs for Individual Radionuclides for the Wildlife Refuge Worker.***
- *Table V-5. Risk Based Deterministic RSALs for Individual Radionuclides for Office Worker (pCi/g)* **replaced by *Table V-5a. Risk-based Point Estimate RSALs for Individual Radionuclides for the Office Worker.***
- *Table V-6. Risk Based Deterministic RSALs for Individual Radionuclides for Open Space User (pCi/g)* **replaced by *Table V-6a. Risk-based Point Estimate RSALs for Individual Radionuclides for the Open Space User.***

The risk-based RSALs for rural resident (Table V-3a) and wildlife refuge worker (Table V-4a) were estimated using both point estimate and probabilistic approaches. In a point estimate approach, the RSAL represents a soil concentration that is protective of the reasonable maximum exposed individual. In a probabilistic approach, a range of values, described as probability distributions, were input to the equations and the output is a range or distribution of RSALs that reflect variability in population. For the probabilistic approach, EPA defines the 90-99th percentiles of a risk distribution as the recommended reasonable maximum exposed range, with the 95th percentile as the starting point for risk-decision making. Because RSAL calculations are inversely related to risk calculations, the reasonable maximum exposed range for RSALs corresponds to the 1st through 10th percentiles, with a recommended starting point at the 5th percentile

The recalculated result appears on the left-hand side **in bold**. The earlier result appears on the right-hand side.

Table V-3a. Risk-based Point Estimate and Probabilistic RSALs for Individual Radionuclides for the Rural Resident

Radionuclide	Target Risk	Probabilistic RME Range[1]			Point Estimate
		10th	5th	1st	
Am-241	1E-04	**145**(135)*	**93** (87)	**39** (37)	70
	1E-05	**14** (13)	**9** (9)	**4** (4)	7
	1E-06	**1.4** (1.3)	**0.9** (0.9)	**0.4** (0.4)	0.7
Pu-239	1E-04	**459**(369)	**306**(248)	**148**(37)	130
	1E-05	**46** (37)	**31** (25)	**15** (13)	13
	1E-06	**4.6** (3.7)	**3.1** (2.5)	**1.5** (1.3)	1.3

[1] 10th to 1st percentiles of RSAL distribution corresponds to 90th to 99th percentiles of risk distribution.
*Values in parenthesis from 10/22/01 draft Task 3 report.

Table V-4a. Risk-based Point Estimate and Probabilistic RSALs for Individual Radionuclides for the Wildlife Refuge Worker

Radionuclide	Target Risk	Probabilistic RME Range[1]			Point Estimate
		10th	5th	1st	
Am-241	1E-04	**435**(351)*	**376**(306)	**295**(243)	291
	1E-05	**43** (35)	**38** (31)	**29** (24)	29
	1E-06	**4.3** (3.5)	**3.8** (3.1)	**2.9** (2.4)	2.9
Pu-239	1E-04	**1464** (758)	**1150** (649)	**700** (496)	665
	1E-05	**146** (76)	**115** (65)	**70** (5)	66
	1E-06	**14.6** (7.6)	**11.5** (6.5)	**7.0** (5.0)	6.6

[1] 10th to 1st percentiles of RSAL distribution corresponds to 90th to 99th percentiles of risk distribution.
*Values in parenthesis from 10/22/01 draft Task 3 Report

The risk-based RSALs for office worker (Table V-5a) and open space user (Table V-6a) were estimated using a point estimate approach instead of a deterministic approach.

The recalculated result appears on the left-hand side **in bold**. The earlier result appears on the right-hand side.

Table V-5a. Risk-based Point Estimate RSALs for Individual Radionuclides for the Office Worker

Radionuclide	Target Risk	Point Estimate
Am-241	1E-04	**369***(511)
	1E-05	**37** (51)
	1E-06	**3.7** (5)
Pu-239	1E-04	**800** (725)
	1E-05	**80** (73)
	1E-06	**8.0** (7.0)

*Values in parenthesis from 10/22/01 Task 3 Report

Table V-6a. Risk-based Point Estimate RSALs for Individual Radionuclides for the Open Space User

Radionuclide	Target Risk	Point Estimate
Am-241	1E-04	**364** (955)*
	1E-05	**36** (96)
	1E-06	**3.6** (9.6)
Pu-239	1E-04	**1126** (1257)
	1E-05	**113** (126)
	1E-06	**11.3** (12.6)

A Focus Group member asked if the adult cancer slope factor was designed to represent an entire lifetime. EPA said that it represented 18 to 65 years of age.

A Focus Group member asked about stewardship and questioned why the Focus Group was not using the most conservative scenario. The Colorado Department of Public Health and Environment (CDPHE) stated that the end state was being viewed with an eye on what would happen over time. With this in mind, areas that were subject to erosion had a role in making decisions about remediation. CDPHE also mentioned that these types of discussions were being held in the Rocky Flats Citizens Advisory Board and the Rocky Flats Coalition of Local Governments.

EPA added that additional calculations were not done on the resident rancher scenario. The RAC group conducted an evaluation, but their methods of calculating mass loading were very different, and the results were considered very, very high by this Focus Group. A similar and representative scenario (rural resident) was recalculated and the differences between the RAC resident rancher and rural resident were considered. **The RAC resident rancher was higher than the rural resident by a factor of 5 due to the fact that the RAC used 8,000mg/m^3 for an annual mass loading average. To provide perspective, EPA described a recent major dust storm in Las Vegas, Nevada. The Las Vegas newspaper reported that particulate matter (PM) counts for that storm were 600mg/m^3 as a 24-hour average. Visibility was so poor, one could not see past ¼ of a mile. Again, the value that the RAC used for their calculations for mass loading was 8,000mg/m^3 as an annual average. It was concluded that no person would live in an environment with PM counts that high.**

RESRAD V6.0 URANIUM RSAL RESULTS FOR ROCKY FLATS

This presentation was organized in thirteen sections:

1. Aspects of the Uranium Problem
2. General Approach;
3. Parameter Sensitivity Investigation
4. Pathway Sensitivity
5. Addressing Uncertainty in Area and Depth of Contamination
6. Addressing Uncertainty in Isotopic Ratios for Uranium
7. Addressing Toxicity
8. Depleted Uranium
9. 20% Enriched Uranium

10. Dose Coefficients
11. Plant Uptake Fraction
12. Results Before Toxicity Adjustments
13. Results Adjusted for Toxicity
14. Summary

Aspects of the Uranium Problem

- Small "hot spots" of uncertain area;
- Primarily subsurface;
- Site has worked with both depleted (DU) and enriched (EU) forms of Uranium;
- Possible wide range of ratios of three isotopes: U238, U235, U234; and
- Toxicity to human kidney must also be considered.

There are small "hot spots" of a wide variety of Uranium mixtures, which are widely dispersed and are not currently well characterized. So far, there exists enriched Uranium, which is processed to create U235 isotope used for weapons and depleted Uranium, which is the residual amount after the Uranium is processed. Uranium contamination is primarily subsurface as it has been buried.

Due to the wide variety of Uranium mixtures, a wide range of ratios are needed for three isotopes: U238, U235, and U234. This made assessing (calculating) human health affects a complex problem. Uranium is a toxic metal and toxicity to the human kidney must be considered as well. It is possible to have radiological criteria that are protective, but still not be protected from toxicity.

General Approach

- Model wildlife refuge worker and rural resident (adult / child) scenarios;
- Use same parameter values and distributions as for Plutonium RSALs if possible;
- Investigate selected additional parameters for sensitivity (area and depth);
- Address uncertainty conservatively.

Currently, three scenarios were modeled: wildlife refuge worker and the rural resident (adult and child). Similar inputs were used in terms of site description and meteorology as used for Plutonium. Since Uranium has many more gamma rays than Plutonium, exposure is still a great concern even though Uranium is buried. Uncertainties were being addressed in a conservative way.

Parameter Sensitivity Investigation

- Area of contamination—very sensitive for small hot spots;
- Depth of contamination—sensitive up to about 40 centimeters for Uranium;
- Plant root uptake fraction for Uranium—a wide range of variability observed.

A full-scale sensitivity analysis was not conducted due to the work already completed for Plutonium. Areas of contamination were reviewed, and it was concluded that areas smaller than 100/m^2 needed to be considered a sensitive parameter, as they generally were characterized as hot spots. Research shows that at the depth of contamination beyond 40 centimeters, the surface soil shielded the gamma rays effectively. In terms of the plant root uptake fraction, it was discovered that for Uranium, the uptake was orders of magnitude higher than Plutonium due to Uranium's behavior while in the soil.

Pathway Sensitivity

- Plant ingestion—dominant for U234;
- External exposure—dominant for U238 and U235;
- Inhalation—always less than 1% of dose.

The pathways will remain the same for all three scenarios: soil ingestion, inhalation, external exposure and the rural resident all included plant ingestion. The scenarios were modeled using the different isotopes: U234, U235, and U238. Plant ingestion is affected primarily by U234. U234 does not contribute to the external exposure. External exposure is primarily from U235 and U238. Soil ingestion contamination from the three isotopes showed very little contribution. For the inhalation pathway, the modeling results have always demonstrated less than 1% of dose, indicating trace amounts of Uranium.

Addressing Uncertainty in Area and Depth of Contamination

- Model a hypothetical large area (5 acres);
- Model hypothetical surface contamination;

- Select 50 centimeters as hypothetical depth of contamination.

A lot of uncertainty exists, so a decision was made to model a hypothetical area of around five acres. This is consistent with the parameter used for the rural resident for Plutonium. To try and model surface contamination, assuming the Uranium was able to move from subsurface to surface, 50 centimeters was determined to be the depth of contamination for the purposes of calculation.

Addressing Uncertainty in Isotopic Ratios for Uranium

- Compute RSAL for each isotope (U238, U235, and U234);
- Compute sum-of-ratios RSALs for both DU and EU (bounding cases);
- Select the most restrictive RSAL as a single criterion;
- Express as total Uranium in mass units (mg/g).

A RSAL and sum-of-ratios were calculated for each isotope for two Uranium cases: depleted Uranium and 20% enriched Uranium. These calculations were based on areas of known Uranium contamination and do not represent areas where only background Uranium exists. Based on these calculations, the most restrictive case would be chosen to represent an RSAL for Uranium. Micrograms per gram (mg/g) was used instead of picoCuries per gram (pCi/g) as a convenient way to measure total uranium in terms of mass per unit of soil instead of in terms of activity. Micrograms per gram enabled a comparison between depleted Uranium and enriched Uranium. When measuring in pCi/g, the isotopic ratio was required and became too complicated for this analysis. In addition, measuring in mg/g was useful for analyzing and comparing toxicity.

Addressing Toxicity

For sum-of-ratios RSALs for depleted Uranium and enriched Uranium:
- Find percentage of dose due to ingestion (plant ingestion plus soil ingestion);
- Back calculate to annual intake, average daily intake;
- Compare with the reference dose for Uranium (RfD=3.0 ug/kg/day);
- Reduce soil action level so reference dose is not exceeded.

To assess toxicity, a formula was used to back calculate annual intake of DU and EU to an average daily intake of depleted and enriched Uranium. The percentage of dose via plant or soil ingestion was calculated first using a computer model. This dose corresponded to millirem radiological dose. Then the percentage of dose was divided by the ingestion dose coefficient (ICRP 72) expressed in millirem per pCi. This was converted to micrograms. This represents the annual intake, which is used to calculate average daily intake. This result was compared with safety standards and the reference dose. If the safety standard or reference dose for toxicity was exceeded, the soil action level was reduced because radiological criteria were not protective enough.

Reed noted that reference dose is not associated with radioactivity; it is associated with heavy metal toxicity.

Depleted Uranium

The following chart showed the difference in percentages of the different isotopes of EU and DU by mass.

Depleted Uranium
1 picoCurie = 2.5 micrograms

Isotope	% by Mass	% Activity
U238	99.75	70
U235	.25	1
U234	.0005	29

U234 makes up a very small amount of DU by mass (.0005), but represents 29% by activity. This is due to the very short half-life relative to U235 and U238.

20% Enriched Uranium

U234 is still a very small amount by mass, but now has 90% of the activity. The range of mass in terms of pCi was great for EU and DU.

20% Enriched Uranium
1 picoCurie = .111 micrograms

Isotope	% by Mass	% Activity
U238	79.95	4
U235	20	6
U234	.05	90

Dose Coefficients

- Taken from ICRP 72;
- Applicable to members of the public;
- Age specific—adults and 1-year old child;
- Only one choice for ingestion coefficient (conservative);
- Used default Type M for inhalation.

The dose coefficients from ICRP 72 are age-specific. For these calculations, the data that are represented are an adult and a 1-year old child. A level of uncertainty was factored into the dose coefficient to help keep the coefficient conservative. The variables that were considered for uncertainty were solubility and form. Uranium tends to be reasonably insoluble, but the dose coefficient uses moderate solubility. Also, if the Rocky Flats Site was not sure what the chemical form of Uranium was at the time of exposure, then using type moderate (Type M) for the inhalation parameter was suggested. It was emphasized that inhalation only represents 1% of the dose according to sensitivity studies.

Plant Uptake Fraction

- Represents fraction of Uranium in soil taken up through plant roots;
- Wide variability observed in studies;
- Influenced by many factors;
- Used a broad distribution in the RESRAD model;
- Modeled more conservatively than the RESRAD default.

Plant uptake fraction represents a fraction of Uranium if the soil is taken up through a plant's roots. After reviewing several studies, the Working Group identified a wide variability in the amount of Uranium that could be taken up through a plant's roots.

Since there was such a complicated relationship with plant uptake, the Working Group made a decision to use a broad distribution for that parameter in RESRAD. This was more conservative than the default value in RESRAD. It was observed that these results were three times higher than the RESRAD default at the 95th percentile. These results were reviewed by Dr. Ward Wicker, and he confirmed that they were conservative.

Results before Toxicity Adjustments

The next two charts, titled *Results (micrograms/grams) Before Toxicity Adjustments* and *Results (micrograms/grams) Adjusted for Toxicity* were calculated using total Uranium. It was found that total Uranium was easier to measure and less expensive to study than isotopic Uranium. For three scenarios, RSALs were calculated. For EU, the RSAL is greater than the two resident scenarios. The RSALs are calculated and expressed in micrograms/grams. It was discovered that scaling of the RSALs was necessary in order to meet toxicity criteria.

Results (micrograms/grams)
Before Toxicity Adjustments

Scenario	DU RSAL	EU RSAL
Rural Resident - Adult	619	31
Rural Resident - Child	692	35
Wildlife Refuge Worker	3268	225

Results Adjusted for Toxicity

Based on the adjusted toxicity results, it was decided that RSAL for the rural resident would be 31mg/g for EU, and for the wildlife refuge worker, the RSAL would be 225mg/g for EU. Both criteria are based on a radiological annual dose of 25 millirem because of the Uranium being enriched.

Results (micrograms/grams)
Adjusted for Toxicity

Scenario	DU RSAL	EU RSAL
Rural Resident - Adult	225	31
Rural Resident - Child	124	35
Wildlife Refuge Worker	3163	225

Summary

- The most restrictive criterion for rural resident scenario is 31 mg/g;
- The most restrictive criterion for wildlife refuge worker is 225 mg/g;
- Both criteria are radiologically based on a 25-millirem annual dose for 20% enriched Uranium; and
- The input parameters were based on many conservative assumptions.

General Discussion

A member of the Focus Group asked for a description of the different forms of Uranium at Rocky Flats and how they were represented in the model. The Focus Group was informed that this information was not easy to extract from the datasets, but consulting with different studies on the subject, the RSALs for Uranium at Rocky Flats reasonably represent the wide range of variability found in the studies. The description of the different forms of Uranium at Rocky Flats would be published in a pathway summary.

One Focus Group member pointed out that the RSAL for EU would result in very high clean up costs because of the potential for cleaning up areas where natural background levels exceed this RSAL.

The RSALs Working Group has been tasked with finalizing the Task 3 Report. The final report will address the Focus Group discussions and the responses to the peer reviews.

The Focus Group was informed that end state discussions and policy discussions concerned with RSALs would be answered in a different forum.

The CDPHE acknowledged all the participants for their hard work. CDPHE stated that Rocky Flats has accelerated its current cleanup schedule and the focus will be on surface contamination cleanup in the risk range of 10^{-5} for the refuge worker.

ADJOURN

The meeting adjourned at 6:00 p.m.

RFCA Stakeholder Focus Group
April 17, 2002
Meeting Minutes

Appendix A
Participants List

Changes to Ur and Am Calculations

- **Adult cancer slope factors used for adult only scenario**
- Distribution used for adult soil intake rate instead of a point estimate
- Point estimates were added
- Spreadsheet revisions per Robert Underwood's comments
- Spreadsheet mistakes the workgroup found (e.g., open space inhalation rates)

Differences between Ur and Pu/Am Calculations

- Inclusion of a non-cancer toxicity assessment based on nephrotoxicity
- Increase in the plant uptake for homegrown fruits and vegetables
  - Uptake factor for uranium is 2-3 *orders of magnitude* greater than that for plutonium and americium

RFCA Stakeholder Focus Group
Attachment A

Title:	Agenda for April 17, 2002 Focus Group Meeting
Date:	April 12, 2002
Author:	C. Reed Hodgin AlphaTRAC, Inc.
Phone Number:	(303) 428-5670
Email Address:	cbennett@alphatrac.com

RFCA Stakeholder Focus Group
Attachment B

Title: March 20, 2002 RFCA Focus Group Meeting Presentations and Handouts, including:

- Agency Response presentations to RSALs Task 3 Report Peer Reviews

Date: April 12, 2002

Phone Number: (303) 428-5670

Email Address: cbennett@alphatrac.com

RFCA Stakeholder Focus Group
Attachment C

Title:	RSALs Working Group Notes for March 28, April 4, and April 11, 2002
Date:	April 12, 2002
Phone Number:	(303) 428-5670
Email Address:	cbennett@alphatrac.com

RFCA Stakeholder Focus Group
Attachment D

Title: April 11, 2002 RSALs Working Group handouts, including:

- Draft RSAL Recalculations: Responding To Task 3 Comments And Quality Checks (RESRAD Dose Calculations Only), and
- Draft Addendum To Task 3 Report: Computations Of RSALs For Uranium Contamination At Rocky Flats Using RESRAD 6.0 (Dose Based Computations)

Date: April 12, 2002

Phone Number: (303) 966-4663

Email Address: robert.nininger@rfets.gov

RFCA Stakeholder Focus Group
Attachment E

Title:	October 3, 2001 RFCA Focus Group Meeting Minutes
Date:	April 12, 2002
Author:	C. Reed Hodgin AlphaTRAC, Inc.
Phone Number:	(303) 428-5670
Email Address:	cbennett@alphatrac.com

DRAFT

RSAL Recalculations: Responding to Task 3 Comments and Quality Checks (RESRAD Dose Calculations Only)

Land Use Scenario	Pu RSAL 10/01 Task 3 Report	Pu RSAL 4/02 Task 3 Recalculation	Am RSAL 10/01 Task 3 Report	Am RSAL 4/02 Task 3 Recalculation
Wildlife Refuge Worker	862	780	132	142
Rural Resident Adult	209	232	32	42
Rural Resident Child	244	251	37	46
Open Space User Adult	11797	3617 *	1801	658 *
Open Space User Child	4842	1205 *	739	219 *
Office Worker	2289	1598 *	350	290 *
RAC Resident Rancher	45	NA	7	NA

Summary Table of Recalculated Values for Sum-of-Ratios Plutonium and Americium RSALs at Rocky Flats: April 2002 – Sum of Ratios Values expressed in picocuries per gram.

Discussion:

The relative increase in values for Americium RSALs for all scenarios is primarily due to the use of an equilibrium ratio for americium (18.2%) representing complete ingrowth at the point of computation of the sum of ratios reference values. The previous calculation used a ratio of 15.3% based on a composite of recent field measurements.

The significant decrease in RSALs identified by asterik (*) is due to a revision in the soil ingestion values for the Open Space User and Office Worker scenarios to make the contaminated soil ingestion amounts consistent with values used in the risk calculations. The previous computations did not correctly incorporate this scenario assumption.

The remaining changes in computed RSALs are primarily due to the use of an adult soil ingestion distribution for the adult scenarios, the use of the higher americium-to-plutonium ratio in the sum-of-ratios calculation, and the use of 1,000 observations per computation as opposed to the 10,000 observations used previously. These changes are not seen as significantly different within the uncertainty of the model calculations.

DISCUSSION PAPER ON VERIFYING RAC RSAL CALCULATIONS USING RESRAD 6.0

Prepared by USEPA

The Citizen's Advisory Board has requested that the RSAL Working Group perform computations of RSALs for the most restrictive scenario modeled by the Risk Assessment Corporation (RAC) in their Task 5 Final Report (resident rancher). In the process of addressing this request, the RSAL Working Group selected the most recent version of RESRAD, Version 6.0, which has the capability of performing Monte Carlo probabilistic calculations using input parameter distributions when desirable. This feature of RESRAD makes it possible to use "realistic" approximations of parameters which are important to the modeling calculations, for which it is difficult or unsound to select a single value (eg. a wide range of values is possible, high uncertainty exists, etc.). Since RAC made extensive use of the Monte Carlo probabilistic approach in the Task 5 calculations, it was felt that the use of RESRAD 6.0 might provide for a more comparable calculation on the part of the RSAL Working Group.

As the Working Group has gained familiarity with the features of RESRAD 6.0, it has become obvious that the probabilistic feature, alone, will not enable the group to replicate the RAC approach or produce a computation of RSALs which can be compared with those calculated by RAC. This is because RAC essentially wrote new computer algorithms (sub-programs) for three of the most sensitive inputs into the RESRAD model used (version 5.82), and turned off the corresponding algorithms in RESRAD. These inputs are the Area of Contaminated Zone, Mass Loading, and Mean Annual Wind Speed. RAC cited limitations in the RESRAD algorithms as reasons for departing from RESRAD's basic computational approach. The alternate approach taken by RAC consisted of a mathematically complex process of empirical curve fitting of soil concentrations, "bootstrap" calculations of resuspension, use of alternate air transport modeling, and iterative "calibration" of the air model to actual air sampler results, as well as incorporation of a five year meteorological database array for the site. (See the final Task 5 Report.) While this alternate approach arguably addresses limitations in RESRAD (note that all computer models are limited by the approximations they use), it is not clear to the Working Group whether RAC's approach constitutes an improvement, or produces a more reliable RSAL value. Whatever the best RSAL approach may be, replication of RAC's approach is certainly outside the scope of the RSAL Working Group, since the group is not equipped to write, test and verify alternative software. Because the Working Group cannot replicate the RAC calculations, it is not possible to select values or distributions for these three key input parameters, based upon RAC's work, which would allow a direct comparison with RAC using RESRAD 6.0.

To fulfill the agreed upon work, the group proposes to model the resident rancher scenario, as described by RAC, using RESRAD 6.0 without modification, noting that the results should be compared with caution to the RAC work. Whenever possible, the input parameters for this scenario will be those used in the RAC Task 5 Report for the resident rancher (adult and child). For the three sensitive parameters cited above, alternative approximation methods, which are considerably simpler than those applied by RAC, but which are still conservative and complete, will be applied. These approximations, described below, have been agreed upon conceptually by a technical subgroup of the working group. They appear to be feasible, and straightforward, given the present site data:

> Area of the contaminated zone. The limitation of RESRAD which RAC attempted to address is that it models based upon a input defined area which is presumed to be uniformly contaminated. RAC attempted to model the contaminated zone, as precisely as possible by using isopleths which were fitted to soil contamination values taken from the RFETS soil database. The subgroup believes that it is possible to greatly simplify this approach if the contaminated zone is approximated as two zones - a smaller zone which is uniformly cleaned up to the RSAL value, and a second, larger zone, which contains all values of contamination ranging from the RSAL value down to background values. These zones would be modeled as concentric circles, with the smaller zone lying within the larger zone. The modeling approach would involve: 1.) Compute the annual dose, D_{res}, to maximally exposed residents due to the large zone (area not cleaned up) using a conservative value for the average contamination (greater than the actual average) and 2.) Derive the RSAL value for the area to be cleaned up, using an adjusted annual dose limit of [25 mrem - D_{res}] as the basis. This approach permits the use of RESRAD without modification, and still accounts conservatively for the impact of the large area of residual contamination.

> Mass loading. RAC noted that versions of RESRAD, available at that time did not admit for the variability of this parameter due to wind speed and direction, and performed complex alternative computation to approximate the mass loading distribution, fitted to a Denver wind rose, and calibrated to local air sampling data. The working group believes that the variability of mass loading can be addressed within the context of RESRAD 6.0 since this parameter can be directly input as a distribution. The approach to developing this distribution, which appears feasible to the technical subgroup, will involve the use of past and recent site specific resuspension data developed or incorporated by MRI, Radian, and the Actinide Migration Panel, including the most recent work involving wind tunnel studies of burned and unburned areas of the site. The relationships between mass loading and wind velocity which these site specific studies provide can be used, in conjunction with site wind rose data (wind velocity and frequency), to construct site specific mass loading distribution curves (shape of the curve determined by frequency) for both the vegetated and denuded case. Although this approach is not comparable with the RAC approach, it is likely to be more conservative, since the dose reduction effect of varying wind direction with respect to the receptor is not incorporated (the computer treats the receptor as always downwind in RESRAD 6.0).

> Average wind speed. RAC incorporated the variability of wind speed in their mass loading model. Likewise, the working group proposes to incorporate the variability of wind speed in the mass loading distribution, described above. A site specific value of average wind speed, based on local meteorological data will be used as the input to RESRAD 6.0 for this parameter.

The working group believes that these approximation methods are sound and will enable the group to proceed toward development of parameter distribution and modeling without undue delay. It is to be noted that the values and distributions of the three parameters described above will be used for all of the scenarios modeled by the RSAL working group, since they represent site conditions which are common to all scenarios.

THE RURAL RESIDENT SCENARIO

As has been stated elsewhere, the working group believes that certain aspects of the resident rancher scenario modeled by RAC are not realistic, given the inherent features of the site, and is performing the modeling of this scenario for comparative purposes only. To address the site resident situation which the group believes is realistic, and will lead to the most restrictive RSALs for the case where institutional controls are absent, the group proposes to model a site specific version of the rural resident scenario, proposed in generic form by USEPA in its Technical Support Document for the Soil Cleanup Rule for Radioactively Contaminated Sites (40 CFR Part 196). This scenario, which will be modeled for both the adult and child cases, is similar in many ways to the RAC resident rancher scenario, with shallow groundwater and meat pathways turned off. There will also be some differences in site usage, breathing rates, and ingestion quantities - the rural resident may be thought of as a suburban worker dwelling on a 5-10 acre farmette, a practice which is not uncommon for the general area at this time. Although the head of the household works away from the site, the modeling will be done using adult and child residents who spend nearly 100% of time on site. The conservative features of this scenario over other EPA residential scenarios (eg. suburban resident) include high site occupancy, soil surface undisturbed by development (no credit taken for pavement, sod cover, etc., as in a typical subdivision), and larger quantities of home-grown vegetables ingested.

DRAFT

ADDENDUM TO TASK 3 REPORT:

COMPUTATIONS OF RSALS FOR URANIUM CONTAMINATION AT ROCKY FLATS USING RESRAD 6.0 (DOSE BASED COMPUTATIONS).

Executive Summary:

Uranium contamination at Rocky Flats is primarily present as subsurface hot spots of relatively small areas of uncertain extent. To address this conservatively, the Working Group elected to model a hypothetical area of surface contamination both large enough (5 acres) and deep enough (50 centimeters) to assure pathway saturation for all principle pathways for the residential and wildlife refuge worker scenarios. Since a relatively broad range of isotopic ratios of uranium isotopes have been used at Rocky Flats, the Group performed the RSAL calculations for the two bounding situations (depleted uranium and 20% enriched uranium) and selected the RSAL which was most restrictive to assure adequate protection with a single criterion. Toxicity of uranium to the human kidney necessitated the application of a test to assure that the radiologically based SAL would be adequately protective in the scenarios modeled. Most of the parameters for the computations are the same as for the plutonium and americium calculations, the principle exception being the use of a lognormal distribution for the plant uptake fraction for uranium, which is observed to be quite variable, influenced by a number of factors such as soil type, plant species type, weather, etc. The principal pathway for the residential scenario is the plant ingestion pathway, which contributes 50-90% of the dose. For the wildlife refuge worker, the principal pathway is the external exposure pathway. In both cases the single criterion for the enriched uranium (31 micrograms per gram for the adult resident, and 225 micrograms per gram for the wildlife refuge worker for the RESRAD dose based computations) proved to be adequately protective both radiologically and toxicologically. Since these criteria were computed using very conservative modeling assumptions (large area of surface contamination) compared to the actual situations to be encountered (small area hot spots of primarily subsurface contamination); the use of hot spot criteria could be considered, to give a more realistic, although still conservative clean-up level.

Introduction:

The problem of uranium contamination at Rocky Flats is fundamentally different from the problem of plutonium and americium contamination that has been addressed in the body of the Task 3 Report. Based upon the information that the Working Group had available the differences may be summarized as follows:

- Uranium contamination occurs in a number of isolated spots at known locations on the site where processing or disposal activities took place. The actual areas of the spots (solar ponds, burn pits, trenches, etc.) are uncertain but estimated to be less than

100 m2 per spot.

- With few exceptions all of the uranium contamination on the site is subsurface contamination, covered by uncontaminated soil. Available subsurface characterization data appear sketchy.

- Two distinct types of uranium were processed at Rocky Flats: depleted uranium, and enriched uranium (presumably of varying degrees of enrichment). Disposal activities of each type appear to have been conducted in different locations, with the possibility of a few locations where both types are present.

In the dose and risk based calculations which the Working Group undertook, the decision was made to not consider groundwater dependent pathways for the scenarios modeled, which were the three principle scenarios from the Task 3 Report – the wildlife refuge worker, and the rural residential (both adult and child) scenario. The decision to suppress groundwater dependent pathways was based upon the premise that the available shallow groundwater is insufficient in both quality and quantity to supply a resident, and would not be used by a refuge worker.

In the absence of groundwater pathways, the current situation of buried contamination in small isolated hot spots presents only incidental exposure routes to either residents or refuge workers, unless the contaminated material is brought to the surface. In that case the material would constitute an exposure hazard to either an adult or child rural resident (as described in the Task 3 Report) through the same four pathways considered (external exposure, inhalation, homegrown plant ingestion, and soil ingestion). The wildlife refuge worker would also be exposed to the same three pathways (external exposure, inhalation and soil ingestion) as described in the Task 3 Report for plutonium and americium.

Approach:

A fundamental difference between the uranium problem and the plutonium problem, assuming that the buried uranium is moved to the surface, is that the area of surface contamination would be much smaller, and much more uncertain in extent, than that of the current surface plutonium contamination on the site, which is fairly well known. Although the Task 3 sensitivity studies showed that the area of the contaminated zone is not a sensitive parameter over the ranges considered appropriate for plutonium (acres to hundreds of acres range), exploration of the sensitivity of this parameter for uranium over areas typical of "hot spots" shows that in the range from 1 - 100 m^2 it is highly sensitive, and from 100 - 1000 m^2 it is moderately sensitive, since some of the more important pathways (plant ingestion and external exposure) are not saturated. This is easy to understand for the most significant pathway for residential exposure to uranium – the plant ingestion pathway. To supply a residential family with home-grown food sufficient to provide the majority (or all) of their fruit and vegetable intake for year long periods, a sizable garden is required, on the order of 1000 -2000 m^2. If only a small area of this garden is contaminated because of a small hot spot, then a correspondingly small fraction of the dietary intake is contaminated – and this will significantly impact the calculation of soil concentrations that meet the target dose or risk.

Faced with the two sources of uncertainty of how much contamination would reach the surface from small buried sources, and the areal extent of such surface contamination, the Working Group chose to address this problem by developing an RSAL for a hypothetical situation of a large area of surface contamination (five acres). The Working Group believes that the approach of modeling a hypothetical large area as a surrogate for a much smaller real area of uncertain size is quite conservative. The three scenarios that were considered for this computation were the Rural Resident (adult and one year old child) and the Wildlife Refuge Worker. With the exception of the contaminants considered, dose conversion factors, area and depth of the contaminated zone and the plant uptake factors (see below), all input parameters, including distributions, were the same as used in the plutonium/americium computations for these scenarios.

A second way in which the uranium calculation differs from the plutonium calculation has to do with the presence of both depleted uranium (DU) and enriched uranium (EU) at Rocky Flats. The isotopic mix of the three uranium isotopes (mass numbers 238, 235 and 234) strongly influences the sum-of-ratios RSALs. For this reason the Working Group has chosen to compute the single radionuclide RSALs using probabilistic RESRAD 6.0, for each of the three isotopes for each scenario, then to compute separate sum-of-ratios RSALs for the case of depleted uranium and enriched uranium, hereafter referred to as DU and EU respectively. For the degree of enrichment (of U235 by weight), the working group chose 20%, since the isotopic activity ratios of the three isotopes remain fairly constant above this enrichment.

For uranium, there is an additional consideration of chemical toxicity. Depending on the isotopic mix of the three principle uranium isotopes (see below), and the resulting activity per unit mass of the resulting mixture, compliance with the radiologically based protective criteria may not be sufficiently protective to assure that the resident would not exceed the safe limit of daily intake of uranium from ingestion of plants and soil (the two active ingestion pathways). This safe limit, referred to as the Reference Dose (RfD), was taken from the Superfund Integrated Risk Information System (IRIS), and represents an average daily intake, which if taken over a long -period of time provides adequate assurance of no chronic adverse effects on the human kidney (proteinuria). The Reference Dose for uranium is 3.0 micrograms per day per kilogram of body weight. Consideration of the chemical toxicity in addition to the radiological protective criterion necessitates that an additional test be made on the calculated RSAL quantities. This test requires that the internal exposure (inhalation and ingestion) components of the modeled annual dose (25 mrem) do not result in average daily intakes exceeding the Reference Dose. If the Reference Dose is exceeded in either the case of depleted or enriched uranium, then additional reductions must be applied to one or both RSALs. This reduction assures that the soil action level does not result in potential average daily intakes that exceed the Reference Dose throughout the range of isotopic mixtures considered.

The final step in the computation of the RSAL for uranium involves the selection of a single value, in micrograms per gram, of either the toxicity-adjusted values for depleted or enriched uranium, whichever is most restrictive. The specification of total uranium by mass (micrograms per gram) instead of specific activity (picocuries per gram) is a useful convention which allows a single protective criterion to be specified for uranium which is independent of the isotopic mixture, allowing it to be more easily measured in field samples.

Mass and Activity Relationships of Uranium:

Most of the information below was taken from the DOE Publication "Health Physics Manual of Good Practices for Uranium Facilities" (EGG-2530, UC-41, June 1988). It is important to distinguish between the percentage of each isotope by weight and by activity. The following table was constructed by taking information from Table 2-1, and from approximate values read from the graph in Figure 2-1 of the subject document.

Isotope	DU weight %	EU weight %	DU activity %	EU activity %
U-238	99.75	79.95 (est)	70	4
U-235	.25	20	1	6
U-234	.0005	.05 (est)	29	90

Table A - Weight and Activity Relationships for Depleted and 20% Enriched Uranium

One of the striking points that can be seen is the amount of U-234 activity present in enriched uranium. This is because it concentrates faster than U-235 in the gaseous-diffusion enrichment process (which favors lighter isotopes), and because its half-life is much shorter than the other two isotopes (activity per gram much higher, or inversely grams per unit of activity much lower).

An empirical formula from the Good Practices Manual relates specific activity to degree of enrichment:

$$S = (0.4 + 0.38E + 0.0034E^2) \times 10^{-6} \text{ Ci/g} \quad \text{where } E = \text{percent enrichment}$$

The specific activity for DU (0.2% U235) is 4E-7 Ci/g, and for 20% EU it is 9E-6 Ci/g. The conversion factors from total activity (pCi) to mass (micrograms or ug) are therefore:

Depleted U: 1 pCi = 2.5ug; or 1 ug = 0.4pCi
Enriched U: 1 pCi = 0.111ug or 1 ug = 9 pCi

These factors were used to convert total activity of the three isotopes in a given mix to mass in micrograms, and to check whether the toxicity based limit (i.e. the Reference Dose) is exceeded for the uptakes (in picocuries) associated with the dose and risk calculations.

Dose Conversion Factors:

Isotope	DCF Type	DCF Adult (mrem/pCi)	DCF Child, Age 1 (mrem/pCi)
U-238	**ingestion**	**.000165**	**.00044**
	inhalation (M)	**.0106**	**.0344**
	inhalation (S)	.03	.0938
U-235	**ingestion**	**.000172**	**.000475**
	inhalation (M)	**.011**	**.0355**
	inhalation (S)	.031	.0948
U-234	**ingestion**	**.00018**	**.000478**
	inhalation (M)	**.013**	**.0409**
	inhalation (S)	.035	.108

Table B: ICRP 72 Dose Conversion Factors for Uranium
(Values in bold were used in these calculations)

- ICRP 72 (DCFs for Members of the Public) lists only one choice for an **ingestion** DCF for each uranium isotope. (Age specific - different values for age categories 3 months, 1 year, 5 year, 10 years, 15 years, and adult.) The DCFs that were used in these calculations are for the adult and 1 year old child (consistent with the Task 3 calculations).

- ICRP 72 lists 3 choices (F, M, and S) based on fast medium and slow absorption from the lung to the blood for **inhalation** DCFs for each uranium isotope. (Age specific as above.) The most conservative DCFs for all uranium isotopes (i.e. highest dose per picocurie inhaled) are those of the S Absorption Type.

- Per ICRP 71 guidance, chemical form alone is not to be used as a sole basis for selection of absorption type in the case of environmental exposure. The studies cited for animals suggest that UO_2 behaves as Type S, other uranium oxides (e.g. UO_3, U_3O_8) show variability between Types M and S, and most other compounds show variability between Types M and F. The recommended default Type in the absence of site specific information is Type M.

- Although there is a significant difference in the value of DCF between the M and the S Absorption Types for each uranium isotope, there is very little impact on dose calculations using RESRAD. Typically 99% of the dose computed in residential scenarios is due to external gamma exposure and plant ingestion, with less than 1% due to inhalation.

Pathway and Parameter Sensitivity:

Deterministic RESRAD runs were done using an adult residential scenario (external, inhalation, soil and plant ingestion pathways active). Single isotope RSALs were calculated for each of the 3 isotopes using ICRP 72 DCFs (Type M for inhalation), and varying the area of the contaminated zone between 100 and 40,000 m2. In addition, the depth of contamination was varied between 1 and 100 cm to observe the effect on the external gamma exposure component. (Since the RSAL for this problem is calculated for a hypothetical situation of large area, the Group felt it was also important to set the depth of contamination at a point where subsurface contamination no longer contributes measurably to external gamma exposure.) The majority of RESRAD parameters at this level of investigation were default values. The following were observed:

- Year 1 gives the lowest RSALs using the default erosion rate and hydrological parameters.

- For U238 and U235, the external exposure pathway dominates (60-98% of dose in first year), with the plant ingestion pathway making up essentially the rest.

- The depth of contamination affects the surface exposure rate up to approximately 40 centimeters. Deeper levels of subsurface contamination are effectively shielded and do not contribute to the external gamma or any other water independent pathway. The Group decided to perform all future uranium calculations using a point estimate of 50 centimeters (to be conservative) for hypothetical depth of contamination.

- For U234, the plant ingestion pathway dominates (80 -90%) throughout the time frame, followed by soil ingestion (10%) and inhalation (7%).

- When the plant ingestion pathway is significant, it is sensitive to the area of the contaminated zone in the range tested. (You need a big enough garden to grow contaminated produce.) However, the external gamma pathway is saturated at small areas, on the order of 300 m2.

Isotope	RSAL for Area 100 m2	RSAL for Area 1000 m2	RSAL for Area 40,000 m2
U-238	455	246	237
U-235	85	66	65
U-234	4927	527	526

Table C: Effect of Area on Single Isotope Potential RSALs (sensitivity investigation - units pCi/g)

If only U238 and U235 were considered for small hot spots, the implication is that external exposure completely dominates the dose, with plant ingestion making a relatively small contribution. For U234, the plant ingestion pathway dominates, implying that plant ingestion becomes more important with a uranium mix having significant U234, such as enriched uranium. With the possibly of calculating RSALs for larger areas, and considering the variability of the plant uptake fraction, the importance of the plant ingestion pathway also increases.

From the above it can be seen that it is necessary to consider the isotopic mix for uranium when establishing pathway and parameter sensitivity, since the constraints of the isotopic mix significantly affect the relative importance of plant ingestion and external exposure pathways. The next series of calculations were performed using isotopic ratios associated with depleted uranium (DU - activity ratios of U238:U235:U234 = 70:1:29), and 20% enriched uranium by weight (EU - activity ratios 4:6:90). The pathway contributions to total dose are displayed for large (40000 m2) and small (100m2) areas. For all calculations the thickness of the contaminated zone is 0.5m, the gamma shielding factor is 0.4, and the plant uptake fraction is 0.02. Note that the plant uptake fraction used for sensitivity studies is almost 10 times higher than the RESRAD default.

Pathway	% dose DU100	% dose DU40K	% dose EU100	% dose EU40K
Plant Ingestion	30.07	76.02	44.31	84.54
External Exp.	68.39	20.89	53.38	12
Soil Ingestion	1.15	2.91	1.7	3.24
Inhalation	0.39	0.19	0.61	0.22

Table D: Pathway percentage contribution for four conditions - sensitivity studies.

The importance of the plant ingestion pathway significantly increases over the single-isotope sensitivity investigations for uranium for four reasons:

- The plant uptake factor has been increased by a factor of 2 over what was previously modeled.

- There is a significant contribution when realistic combinations of all three isotopes are included, particularly U-234 which contributes to ingestion pathways but not to external exposure pathways.

- The gamma shielding factor has been reduced to 0.4 (the current default value for the EPA Soil Screening Guidance). Selection of this value reduces the contribution from external exposure. Previous calculations used 0.7, the RESRAD default.

- Areas large enough to saturate the plant ingestion pathway are being considered.

The increasing importance of ingestion introduces the need to establish a good value or distribution for the plant uptake fraction, and also the need to consider uranium toxicity as well as radiological dose and risk. Consistent with the approach used for the plutonium calculation, the Working Group used the same distributions for plant ingestion quantities, and also investigated the variability of the plant uptake factor for uranium through a review of the literature. This investigation resulted in the selection of a lognormal distribution for the plant uptake factor having a 95^{th} percentile value of .00645 (a factor of 2.6 times higher than the RESRAD default value - see below)

Soil ingestion is addressed by use of the same distributions for adult resident, child resident and wildlife refuge worker as used in the Task 3 Report. Recall that the adult soil ingestion rate is represented as a uniform distribution (all values from maximum to minimum have equal probability) with minimum value 0 and maximum 130 milligrams per day for adults (0 - 47.45 grams per year - see below). This ingestion rate of contaminated soil is assumed to occur over a 24-hour period for each day that the adult resident is on the site, but over an 8-hour workday for each day the wildlife refuge worker is on the site. Owing to the way that RESRAD apportions the intake of contaminated soil over the course of a year, it is necessary to introduce the uniform distribution (0 - 47.45 grams/year) for the resident and (0 - 142.35 grams/year) for the refuge worker, to ensure that the above conditions are met.

To summarize the sensitivity studies, the Working Group has concluded that the same fixed and distributed values of parameters should be used in the uranium calculations as for the plutonium and americium calculations, with the addition of a different approach for the area of the contaminated zone (use of a hypothetical 5 acre contaminated zone), use of 50 cm. for depth of the contaminated zone as opposed to 15 cm for the Task 3 calculations, and the introduction of a distribution for the plant uptake fraction for uranium.

Determination of Plant Uptake Fraction Distribution for Uranium:
(To be inserted)

Computation Procedure:

For each scenario a separate RESRAD 6.0 run was performed using 1000 observations for each of the three uranium isotopes, initially present at 100 pCi/g. From the dose distribution table the total dose from uniform contamination of 100 pCi/g corresponding to 95% cumulative probability was read off for the year of maximum dose (year 0 in all cases). This dose was used to scale the single radionuclide soil concentration to that which would result in 25 mrem annual dose. This value is expressed as the single nuclide RSAL in Tables E, F and G. Following this, the sum-of-ratios RSALs for depleted uranium (70:1:29 isotopic ratios) and 20% enriched uranium (4:6:90 ratios) was calculated for each scenario, and also presented in Tables E, F and G. This run was also used to establish the fraction of the total dose of 25 mrem which was attributable to ingestion (combined soil and plant ingestion), for comparison with the toxicity Reference Dose. The inhalation component was ignored in this calculation since the inhalation contributions for both scenarios were less than 1% of the total dose. The ingestion component (expressed as mrem/yr.) was converted to micrograms per kilogram per day. This component is calculated by dividing the mrem/yr ingestion component by the average ingestion DCF of 0.00017 mrem/pCi for adults or .00046 mrem/pCi for children (from Table B), multiplying that result by the appropriate conversion factor for DU or EU in micrograms per pCi, and scaling to an average daily intake for a 70 kilogram adult or a 15 kilogram child. These results are presented in Tables E, F and G as well. The average daily intake per kilogram of body weight is scaled from the annual mass intake by dividing by the number of exposure days per year for an RME individual (350 for a resident, 250 for a wildlife refuge worker) and dividing this result by 70 kg for an adult, or 15 kg for a child.

Dose Computation Results:

Isotope	Single Nuclide RSAL	SOR RSAL (DU)	SOR RSAL (EU)
U 238	227 pCi/g	173 pCi/g	11 pCi/g
U 235	75 pCi/g	2.5 pCi/g	17 pCi/g
U 234	350 pCi/g	72 pCi/g	254 pCi/g
	% of Dose Due to Ingestion	55%	71.6%
	Average Daily Intake (ug/kg/day)	8.25 ug/kg/day	0.5 ug/kg/day

Table E: 95% Cumulative Probability Results for Rural Resident - Adult Scenario

Isotope	Single Nuclide RSAL	SOR RSAL (DU)	SOR RSAL (EU)
U 238	254 pCi/g	194 pCi/g	13 pCi/g
U 235	78 pCi/g	2.8 pCi/g	19 pCi/g
U 234	401 pCi/g	80 pCi/g	284 pCi/g
	% of Dose Due to Ingestion	70%	71.6%
	Average Daily Intake (ug/kg/day)	16.7 ug/kg/day	0.74 ug/kg/day

Table F: 95% Cumulative Probability Results for Rural Resident - Child Scenario

Isotope	Single Nuclide RSAL	SOR RSAL (DU)	SOR RSAL (EU)
U 238	1059 pCi/g	915 pCi/g	81 pCi/g
U 235	221 pCi/g	13 pCi/g	122 pCi/g
U 234	4901 pCi/g	379 pCi/g	1826 pCi/g
	% of Dose Due to Ingestion	14.7%	35.7 %

	Average Daily Intake (ug/kg/day)	3.1 ug/kg/day	0.3 ug/kg/day

Table G: 95% Cumulative Probability Results for Wildlife Refuge Worker Scenario

Discussion:

- The sum-of-ratios RSAL values for DU and EU can be expressed as total uranium in micrograms per gram of soil:

Scenario	DU RSAL	EU RSAL
Adult Resident	619	31
Child Resident	692	35
Wildlife Refuge Worker	3268	225

Table H: Sum of ratios RSAL

- In all scenarios, the DU radiological SALs result in exceeding the RfD for toxicity. If the SAL s are scaled to values which do not exceed the RfD, the following results occur:

Scenario	DU SAL	EU SAL
Adult Resident	225	31
Child Resident	124	35
Wildlife Refuge Worker	3163	225

Table I: Soil action level accounting for toxicity

- The most restrictive adult residential RSAL for total uranium is that which is radiologically based on enriched uranium. The value of 31 ug/g for this SAL is above the range of normal background levels for uranium (Note that background uranium is usually in a natural isotopic ratio very different than that of enriched uranium).

- For the presence of institutional controls, the most restrictive Wildlife Refuge Worker RSAL is for enriched uranium at 225 ug/g.

- The plant ingestion pathway is the greatest contributor to dose for residents. This is primarily due to the broad distributions used for leafy and non-leafy plant ingestion quantities, and to the use of the broad distribution for plant uptake factor.